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in this slow manner, but civilized man everywhere tends to a close conformity in size, as he also does in conditions of existence. Thus any future change in the average size of man must be of very slow evolution. Its direction will probably be towards greater bulk.

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PRELIMINARY NOTE ON SOME FOSSIL FISHES RECENTLY DISCOVERED IN THE SILURIAN ROCKS OF NORTH AMERICA.

BY PROFESSOR E. W. CLAYPOLE.

I.

THE lowest Old Red Sandstone of Scotland, the argillaceous slates of Cornwall and the calcareo-argillaceous beds of Ludlow in England, have furnished the most ancient fossils yet published which can be attributed to the class of fish. The first and second of these horizons are included in the Devonian system, the third, which is also the most ancient, forms the upper part of the Silurian.

Except two species of Onchus (*O. murchisoni* and *O. tenuistriatus*) all these fossils are referred to the abnormal family of Cephalaspids—a family so abnormal that some zoölogists have seriously doubted if its members were really entitled to the name of fishes. But evidence recently obtained has, in the opinion of those who have specially studied them, Professors Huxley and Lankester, satisfactorily settled the question in their favor, and they are now, with general consent, retained among the vertebrates, of which they form the most ancient type hitherto recognized.

Fossil fish have been reported from rocks called Silurian in Bohemia and in Russia, but the genera and species present an aspect so decidedly Devonian, judging by the English strata, that it is not easy to correlate the two. Asterolepis, Gompholepis, Coccosteus and Ctenacanthus can scarcely be paralleled with the more primitive types of the English Ludlow above alluded to.

No species of fish has yet been published from the Silurian rocks of America, or even from the Lowest Devonian. The most ancient fossils of this class which the western continent has yielded have been found in the Corniferous limestone of Ohio and the beds at Campbellton near Gaspé in Canada. Of these the latter is probably rather the older of the two, as it contains

Cephalaspis, which has not yet been reported from the former locality. The two species known are: *Cephalaspis dawsoni*, *Cephalaspis campbelltonensis.*

During my recent work on the palæontology of Pennsylvania I found some fossils much resembling the well-known specimens from the "Ludlow beds" of England, which for fifty years have been the oldest known fishes. They were an Onchus and two kinds of shields very close in outward form to the Scaphaspis of Lankester.

The study of these fossils has proved that this resemblance is not merely superficial, and that there unquestionably existed, both in Pennsylvania and in England, similar species of fish which characterized the Upper Silurian era in both continents.

The shield, like that of Scaphaspis, as described and figured by Huxley (*Q. J. G. S.*, Aug., 1858), consists of three layers. The inner layer is thin and homogeneous, having a thickness of about $\frac{1}{240}$ of an inch. On this reposes a cellular layer about $\frac{1}{80}$ of an inch in thickness, the walls of which are composed of the same material. These cells open on the interior surface by round pores which traverse their floor, that is, which pass through the inferior layer of the shield. The cells also communicate by openings in their covering layer with a system of canals lying above them.

The outer layer has a thickness of about $\frac{1}{120}$ of an inch, and is composed of the same material as the two already described. It is traversed from end to end by two systems of vessels of which the lower is immediately above the cellular layer, with which it communicates by the openings above mentioned. The canals of this system have a diameter of about $\frac{1}{240}$ of an inch, and from their sides issue branches almost as large as themselves. These branches communicate with another system of canals (or furrows) a little above them and rather less in size, running parallel with them from end to end of the shield under the superficial striation.

Connected with the former of the two systems of canals, and springing from its upper surface, is a delicate and beautiful thicket of minute branching tubules, becoming continually smaller and smaller until they terminate at the outer surface of the shield. Under the microscope they stand out distinctly in black on the transparent background of the material which composes the layers and present a beautiful spectacle with an objective of a fourth or a fifth of an inch.

This description coincides in all details of importance with those given by Professor Huxley in his figure of Scaphaspis. But in several minor points of structure there are differences which make it doubtful if the specimens here described can be referred to that genus. The most conspicuous of these is the regularity and parallelism of the vessels in the outer layer, a feature not shown in any already described species of Pteraspid, so far as I have been able to ascertain. This and some other distinctive features have induced me to place them in a new genus under the name of Palæaspis, in which they constitute two species: *Palæaspis americana*, *Palæaspis bitruncata.*

Accepting the usual correlation of the Upper Silurian rocks of Britain and America, according to which the Ludlow rocks are the stratigraphic and palæontologic equivalents of the Lower Helderberg, the lowest bed of the latter, the Water Lime must lie on the horizon of the English Lower Ludlow. The last is the lowest fish-bearing stratum known in Europe, and has thus far yielded only a single specimen. This, the earliest vertebrate fossil hitherto known, is, as Lankester remarks, enormously older than its kindred fossils from the Upper Ludlow, the bone bed of which has yielded numerous specimens both of the same species (*Scaphaspis ludensis*) and of others.

The fossils above mentioned were found in a stratum which, in my report on the geology of Perry county, now in the press, I have named the "Bloomfield sandstone." It lies at the top of the variegated shale or marl, the middle portion of the great mass of the Onondaga. This—the upper part of the fifth group of Rogers in the first survey of Pennsylvania—is about 1500 feet thick and almost barren of fossils. The only species, excepting those here described, with which I have met in the county, is the well-known crustacean, *Leperditia alta.* This shale is divided into three parts:

Lower Helderberg, water lime.

Onondaga....	Gray marl	200 feet.
	Variegated marl	700 "
	Red shale	700 "

The "Bloomfield sandstone" consists of a series of thin red and gray beds separating the variegated from the gray marl. The fossils have not been found generally diffused over the exposure of the rock in the county but in only a few places. Probably if it were more accessible they would prove to be more abundant. They are seldom in a good state of preservation, but fragments capable of exhibiting the structure are abundant in some places.

From the above facts it may be inferred that the Pennsylvania fossil, Palæaspis, is somewhat older than the unique *Scaphaspis ludensis* of the English Lower Ludlow, and therefore considerably older than the specimens of Scaphaspis and Cyathaspis ? that have been found in the Upper Ludlow.

A thousand feet lower down, in the middle of the red shale, I have met with a thin bed full of comminuted fish-scales or shields resembling in many points those of Palæaspis. Their matrix presents some resemblance to coprolites, but their condition is too imperfect to allow of description.

Nor is this quite the whole. Five hundred feet lower still, below beds indisputably of Clinton age, as determined by their fossils, among which are *Calymene clintoni*, *Beyrichia lata*, *Hormoceras vertebratum*, lies the well-known iron sandstone of the Clinton group of Pennsylvania. In this is a thin layer thickly charged with comminuted scales in much better condition than those in the red shale. With these occurs a spine somewhat like those from the Bloomfield sandstone, and which I have named *Onchus clintoni.*

Associated with these are great numbers of small pellets which present all the characters of coprolites, and may be referred almost with certainty to that group of objects, being in great part composed of phosphate of lime.

It is evident that in these fossils we have the most ancient relics of vertebrate life yet known from any part of the world. At the same time, though carrying the existence of fishes down through at least 1500 feet of strata and back through a corresponding lapse of time, it must be added that these fossils do little or nothing to bridge over the chasm existing between the vertebrates and the invertebrates. Odd and aberrant from the type as they are, they cannot logically be excluded from the class of fish, and though we know nothing of their soft parts, it is reasonable to believe they were arranged as in their nearest allies of which we know anything, Cephalaspis and Coccosteus.

Yet on the other hand, though these particular fossils throw no light on the connection between vertebrates and invertebrates, it is an indisputable fact that the whole group to which they belong, including Pteraspis, Cyathaspis, Scaphaspis and Palæaspis is marked off by a remarkable peculiarity of structure from every known vertebrate animal. So conspicuous is this character that by its aid we are able to distinguish the smallest fragment of their bony shields from all other bone whatever. Not a trace can be seen in them of the peculiar structure which to the anatomist characterizes true bony tissue. The bone cells (lacunæ) and the tubules (canaliculi) connecting them are totally absent. Nor can the Haversian canals, which are usually present in bone, be discovered. So important is this fact that the unwillingness of some naturalists to admit them among vertebrates was natural and defensible. Nor was this unwillingness overcome until the discovery of a specimen showing a few scales attached to the matrix behind the shield afforded indisputable proof of their ichthyic affinity.

The profound significance of this fact has not yet, it appears to me, been fully appreciated by systematists, nor has the fact itself received the recognition to which it appears to be entitled. Probably the obscurity in which these organisms have been hidden, their imperfection and their local and individual scarcity have contributed to bring about this result. Yet it is hard to avoid the conviction that in this immense anatomical difference there may be concealed at least one stone of the bridge that shall some day span the gulf now separating the vertebrates and invertebrates, and that in this approximation to a simpler structure we may see a link between the highly complex tissue of true bone and that simpler and more homogeneous material of which the hard parts of animals lower in the scale are composed. It can be but one link; others would still be wanting. The relative positions of the hæmal and neural elements would present the same difficulty, and the riddle propounded by these will perhaps be never read, as the soft parts are not likely to be preserved.

In thus carrying down the remains of fish almost to the base of the Upper Silurian rocks, it becomes evident that we must seek in some part of our Cambro-silurian series to find yet earlier forms. It is not likely that these are the first that existed. Lower beds must be searched. Pander's "Conodonts" may yet take their place among vertebrates, and fossils older than they may come to light before we can say we have found "the missing link," if such ever existed—the Ichthyic Archetype.